



# 2015 CAPS Spring Forecast Experiment Program Plan

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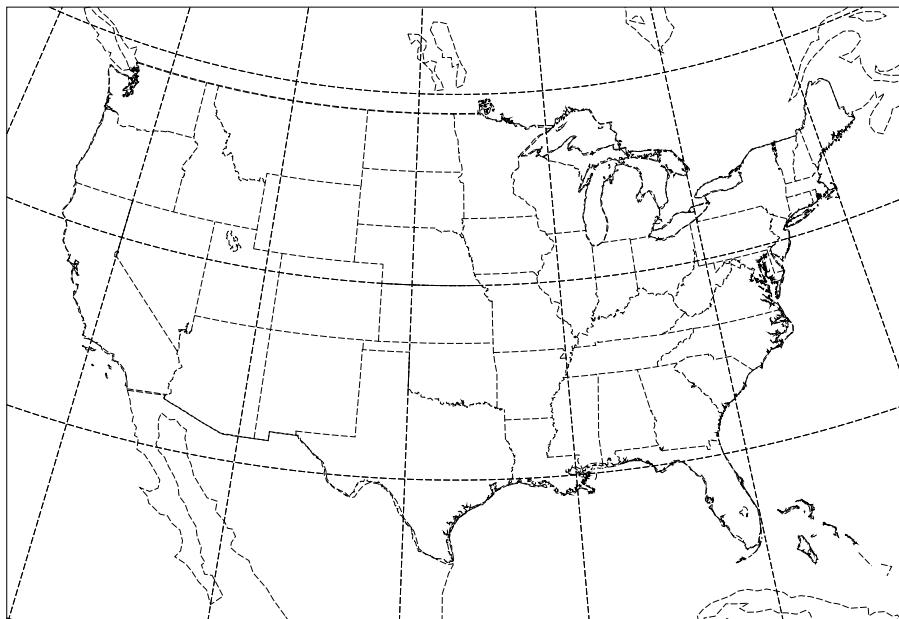
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# 1. Overview of New Features for 2015 Season

## Major features for 2015:

- **3-km** horizontal grid spacing over the CONUS domain ( $1680 \times 1152$ , Figure 1)
- **WRF version 3.6.1** is used for 2015 season. (coupled with ARPS v5.3.6)
- Two SSEF suites:
  - A **3DVAR-based SSEF** (baseline) at 3-km with **20** ARW members, initiated with 3DVAR analysis at 0000 UTC, with up to 60-h forecast, running on **Stampede** at TACC
  - **EnKF-based ensemble forecast**: with up to 40-member storm-scale ensemble background, a one hour EnKF cycling at 15 min interval, and a 12-member ensemble forecast (up to 60-h) starting at 0000 UTC, running on the same CONUS domain (see Figure 1). One deterministic forecast initiated at 0000 UTC with the EnKF mean, and another with cycled 3DVAR analysis are also produced. Running on **Darter** at NICS
- 3D visualization
  - 3D fields from the control run covering a  $200 \times 200$  grid-point area (600 km x 600 km) region will be extracted from the CONUS domain and shipped to the NWC in real-time and 3D visualized fields made available to the forecast teams.



*Figure 1. The computational domain for the 2015 Season for both 3DVAR and EnKF forecasts (3-km grid spacing,  $1680 \times 1152$  horizontal grid points).*

## 2. Program Duration

From **20 April 2015** through **5 June 2015**

The 2015 SPC/NSSL HWT Spring Forecast Experiment, a joint effort among NOAA Storm Prediction Center (SPC) and National Severe Storm Laboratory (NSSL) and the Center for Analysis and Prediction of Storms (CAPS) at University of Oklahoma, will officially **start on 4 May and end on 5 June**, with five days a week (Monday through Friday). CAPS 2015 Spring Program begins regular forecast production two weeks earlier on 20 April to identify possible issues, and remains five days a week (running forecasts on the night of Sunday through Thursday) with possible weekend runs upon SPC request according to weather circumstance.

### 3. SSEF Configuration

WRF-ARW is used in the 2015 Spring Forecast Experiment. All forecasts use **51** vertical levels. WRF code (V3.6.1) was modified by CAPS to allow initial hydrometeor fields generated from 3DVAR/ARPS Cloud analysis of WRS-88D radar reflectivity to pass into WRF initial condition, and (for ARW) to write out reflectivity field every 6 min.

#### 3.1 3DVAR Baseline SSEF initialized at 0000 UTC

SSEF forecasts are generated with the Weather Research and Forecast (WRF) modeling system (**Version 3.6.1**), with the Advanced Research WRF (ARW) core. As in 2014 season, the 00Z NAM analyses available on the 12 km grid (218) are used for initialization of control and non-perturbed members and as first guess for initialization of perturbed members with the initial condition perturbations coming directly from the NCEP Short-Range Ensemble Forecast (SREF). SREF data with Grid 132 data form are directly processed. WSR-88D data, along with available surface and upper air observations, are analyzed using ARPS 3DVAR/Cloud-analysis system. Forecast output at hourly intervals (higher time frequency output for a limited selection of 2D fields, and of 3D full dump for the visualization application) are archived at the TACC mass storage facility.

The *daily* ensemble forecast configuration includes the following, all of which are run on **Stampede**, a Dell C8220 supercomputer system with over 6400 Intel Xeon Phi computing nodes at TACC. CAPS SSEF forecasts will have dedicated access to the system over the project period.

- **ARW:** 20-member ensemble at 3-km grid spacing initialized at 0000 UTC. Model execution begins around 0130 UTC (8:30pm CDT) and finish in 6-8 hours, with results being processed as they become available. **Table 1** lists the configuration and physics options for each ARW member. All forecasts are up to 60-h.

*Table 1. Configurations for ARW members. NAMa and NAMf refer to 12 km NAM analysis and forecast, respectively. ARPSa refers to ARPS 3DVAR and cloud analysis.*

Member	IC	BC	Radar data	Microphy	LSM	PBL
*arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ

arw_c0	00Z ARPSa	00Z NAMf	no	Thompson	Noah	MYJ
arw_m3	arw_cn + nmmmb-p2_pert	21Z SREF nmmmb-p2	yes	P3	Noah	MYNN
*arw_m4	arw_cn + nmmmb-n2_pert	21Z SREF nmmmb-n2	yes	M-Y	Noah	YSU
*arw_m5	arw_cn + nmm-p1_pert	21Z SREF nmm-p1	yes	Morrison	Noah	MYNN
*arw_m6	arw_cn + nmmmb-n1_pert	21Z SREF nmmmb-n1	yes	M-Y	Noah	MYJ
arw_m7	arw_cn + nmmmb-p1_pert	21Z SREF nmmmb-p1	yes	P3	Noah	YSU
*arw_m8	arw_cn + em-n1_pert	21Z SREF em-n1	yes	P3	Noah	MYJ
arw_m9	arw_cn + em-p2_pert	21Z SREF em-p2	yes	M-Y	Noah	MYNN
*arw_m10	arw_cn + nmmmb-n3_pert	21Z SREF nmmmb-n3	yes	Morrison	Noah	YSU
*arw_m11	arw_cn + nmmmb-p3_pert	21Z SREF nmmmb-p3	yes	Thompson	Noah	YSU
*arw_m12	arw_cn + nmm-n3_pert	21Z SREF nmm-n3	yes	Thompson	Noah	MYNN
arw_m13	arw_cn + nmm-p2_pert	21Z SREF nmm-p2	yes	Morrison	Noah	MYJ
arw_m14	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYNN
arw_m15	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	YSU-T
arw_m16	00Z ARPSa	00Z NAMf	yes	Thompson ICLOUD=3	Noah	YSU-T
arw_m17	00Z ARPSa	00Z NAMf	yes	MY	Noah	MYJ
arw_m18	00Z ARPSa	00Z NAMf	yes	P3-cat2	Noah	MYJ
arw_m19	00Z ARPSa	00Z NAMf	yes	P3	Noah	MYJ
arw_m20	00Z ARPSa	00Z NAMf	yes	Morrison	Noah	MYJ

Note 1: For all members: *ra\_lw\_physics*=RRTMG; *ra\_sw\_physics*=RRTMG; *cu\_physics*=none

Note 2: YSU-T is the Thompson modified YSU PBL scheme

Note 3: member arw\_m16 accounts for sub-grid scale clouds in the RRTMG radiation scheme based on research by G. Thompson.

Note 4: arw\_m18 uses the newly developed P3 (Morrison-Milbrandt) microphysics with two-category ice; all other P3 members are with one-category ice.

**\*\* Members in red are contributing members for HWT Baseline SSEF (12 totals).**

### 3.2 EnKF-based SSEF initialized at 0000 UTC

A six-hour EnKF cycling process, starting at 1800 UTC, with 40 WRF-ARW members is performed at the 3-km grid over the CONUS domain. This ensemble is configured with initial perturbations and mixed physics options to provide input for EnKF analysis. Each member uses WSM6 microphysics with different parameter settings (see Table 2). All members also include random perturbations with recursive filtering of ~20 km horizontal correlations scales, with relatively small perturbations (0.5K for potential temperature and 5% for relative humidity). EnKF analysis (cycling), with radar data and other conventional data, is performed from 2300 to 0000 UTC every 15 min over the CONUS domain, using as background the 40-member ensemble in Table 2. A 12- member ensemble forecast (up to 60-h) follows using the last EnKF analyses at 0000 UTC (see Table 3). In addition, two deterministic forecasts, one from the ensemble mean analysis at 0000 UTC and another from 3DVAR analysis, are also produced. This suite of forecasts will be run On Darter at NICS.

*Table 2. Configuration for the EnKF ensemble*

Member	IC	BC	Microphy – WSM6 (N0r, N0g, pg)*	LSM	PBL
enk_m1	18Z NAMa	18Z NAMf	(8,6),(4,6),500	Noah	MYJ
enk_m2	enk_m1 + em-p1_pert	15Z SREF em-p1	(8,6),(4,6),500	Noah	YSU
enk_m3	enk_m1 + nmm-n2_pert	15Z SREF nmm-n2	(9.4,6),(5,4),673	Noah	MYJ
enk_m4	enk_m1 + em-n2_pert	15Z SREF em-n2	(2.4,7),(5.7,4),666	Noah	ACM2
enk_m5	enk_m1 + nmm-p2_pert	15Z SREF nmm-p2	(3.7,7),(6.3,4),659	Noah	ACM2
enk_m6	enk_m1 + nmm-p1_pert	15Z SREF nmm-p1	(2.5,6),(8,4),652	Noah	MYNN
enk_m7	enk_m1 + nmm-n1_pert	15Z SREF nmm-n1	(2.6,7),(9,4),645	Noah	MYJ
enk_m8	enk_m1 + nmm-p1_pert	15Z SREF nmm-p1	(6.8,6),(1,5),638	Noah	YSU
enk_m9	enk_m1 + em-n1_pert	15Z SREF em-n1	(3,6),(1.1,5),631	Noah	MYJ
enk_m10	enk_m1 + em-p2_pert	15Z SREF em-p2	(8.4,6),(1.3,5),624	Noah	MYNN
enk_m11	enk_m1 + nmm-n3_pert	15Z SREF nmm-n3	(1.5,7),(1.4,5),617	Noah	MYJ
enk_m12	enk_m1 + nmm-p3_pert	15Z SREF nmm-p3	(3.1,6),(1.6,5),610	Noah	YSU

enk_m13	enk_m1 + em-p3_pert	15Z SREF em-p3	(8.6,5),(1.8,5),603	Noah	ACM2
enk_m14	enk_m1 + nmm-p2_pert	15Z SREF nmm-p2	(4.6,6),(2,5),596	Noah	MYNN
enk_m15	enk_m1 + em-p1_pert	15Z SREF em-p1	(1.3,7),(2.2,5),589	Noah	MYNN
enk_m16	enk_m1 + nmm-n2_pert	15Z SREF nmm-n2	(5.1,6),(2.5,5),582	Noah	ACM2
enk_m17	enk_m1 + em-n2_pert	15Z SREF em-n2	(8.1,5),(2.8,5),575	Noah	MYJ
enk_m18	enk_m1 + nmmb-p2_pert	15Z SREF nmmb-p2	(1.9,6),(3.2,5),568	Noah	ACM2
enk_m19	enk_m1 + nmm-p1_pert	15Z SREF nmm-p1	(3.9,7),(3.6,5),561	Noah	MYJ
enk_m20	enk_m1 + nmmb-n1_pert	15Z SREF nmmb-n1	(2.2,6),(4,5),554	Noah	ACM2
enk_m21	enk_m1 + nmmb-p1_pert	15Z SREF nmmb-p1	(8.5,6),(4.5,5),547	Noah	MYJ
enk_m22	enk_m1 + em-n1_pert	15Z SREF em-n1	(1.1,7),(5,5),540	Noah	MYJ
enk_m23	enk_m1 + em-p2_pert	15Z SREF em-p2	(8.1,5),(5.7,5),533	Noah	YSU
enk_m24	enk_m1 + nmmb-n3_pert	15Z SREF nmmb-n3	(1,7),(6.4,5),526	Noah	MYNN
enk_m25	enk_m1 + nmmb-p3_pert	15Z SREF nmmb-p3	(2.2,7),(7.1,5),519	Noah	MYNN
enk_m26	enk_m1 + em-p3_pert	15Z SREF em-p3	(7.2,6),(8,5),512	Noah	MYJ
enk_m27	enk_m1 + nmm-p2_pert	15Z SREF nmm-p2	(8.9,6),(9,5),505	Noah	YSU
enk_m28	enk_m1 + nmmb-p3_pert	15Z SREF nmmb-p3	(2.9,7),(1,6),498	Noah	ACM2
enk_m29	enk_m1 + em-p3_pert	15Z SREF em-p3	(1.1,7),(1.1,6),491	Noah	MYNN
enk_m30	enk_m1 + nmm-p2_pert	15Z SREF nmm-p2	(9.6,6),(1.3,6),484	Noah	MYJ
enk_m31	enk_m1 + em-p1_pert	15Z SREF em-p1	(3.1,6),(1.4,6),477	Noah	YSU
enk_m32	enk_m1 + nmm-n2_pert	15Z SREF nmm-n2	(1.3,6),(1.6,6),470	Noah	MYNN
enk_m33	enk_m1 + em-n2_pert	15Z SREF em-n2	(2,6),(1.8,6),463	Noah	MYJ
enk_m34	enk_m1 + nmmb-p2_pert	15Z SREF nmmb-p2	(4.4,6),(2,6),456	Noah	YSU
enk_m35	enk_m1 + nmm-p1_pert	15Z SREF nmm-p1	(1.7,6),(2.2,6),449	Noah	ACM2

enk_m36	enk_m1 + nmmmb-n1_pert	15Z SREF nmmmb-n1	(4.3,6),(2.5,6),442	Noah	MYNN
enk_m37	enk_m1 + nmmmb-p1_pert	15Z SREF nmmmb-p1	(1.3,6),(2.8,6),435	Noah	MYNN
enk_m38	enk_m1 + em-n1_pert	15Z SREF em-n1	(9.1,5),(3.2,6),428	Noah	MYJ
enk_m39	enk_m1 + em-p2_pert	15Z SREF em-p2	(5,6),(3.6,6),421	Noah	YSU
enk_m40	enk_m1 + nmmmb-n3_pert	15Z SREF nmmmb-n3	(6.1,6),(3.9,6),414	Noah	MYJ

\* For N0r and N0h, (a, b) are coefficients of  $a \times 10^b$ .

Table 3. Configuration for the EnKF 12-member ensemble forecasts

Member	IC	BC	Microphysics	LSM	PBL
enkf_cn	enk_m1a	00Z NAMf	Thompson	Noah	MYJ
enkf_m6	enk_m2a	21Z SREF nmmmb-n1	M-Y	Noah	MYJ
enkf_m9	enk_m6a	21Z SREF em-p2	M-Y	Noah	MYNN
enkf_m10	enk_m8a	21Z SREF nmmmb-n3	Morrison	Noah	YSU
enkf_m5	enk_m10a	21Z SREF nmm-p1	Morrison	Noah	MYNN
enkf_m4	enk_m12a	21Z SREF nmmmb-n2	M-Y	Noah	YSU
enkf_m3	enk_m17a	21Z SREF nmmmb-p2	P3	Noah	MYNN
enkf_m8	enk_m23a	21Z SREF em-n1	P3	Noah	MYJ
enkf_m7	enk_m26a	21Z SREF nmmmb-p1	P3	Noah	YSU
enkf_m12	enk_m37a	21Z SREF nmm-n3	Thompson	Noah	MYNN
enkf_m11	enk_m39a	21Z SREF nmmmb-p3	Thompson	Noah	YSU
enkf_mn_t hom	enfamean_thom	00Z NAMf	Thompson	Noah	MYJ
enkf_mn_wsm6	enfamean_wsm6	00Z NAMf	WSM6	Noah	MYJ
enkf_3dvar thom	3dvar_thom	00Z NAMf	Thompson	Noah	MYJ

enkf_3dvar wsm6	3dvar_wsm6	00Z NAMf	WSM6	Noah	MYJ
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## 4. Forecast Product and Deliverables to HWT

### 4.1 Products available to HWT (NSSL/SPC, HPC) in GEMPAK

The NSSL/SPC required list of forecast fields for 2015 HWT Spring Experiment is listed in Table 4. Variables with field name underlined are hourly maximum. These fields will be provided from both the 3DVAR and EnKF ensembles.

In order to keep realtime data flow into NSSL/SPC server manageable, the NSSL/SPC GEMPAK fields are over a sub-domain with edges on all four sides trimmed off. Figure 2 is the desired sub-domain (1430×872 grid points in horizontal), which reduces by about one third of full-domain data size. A complete set of extracted 2D fields (Table 6) over the full CONUS domain are archived by CAPS for post-analysis and external collaborations.

Two separate sets of variables may also be packaged for NSSL/SPC:

- 1) Composite, 1km, -10C reflectivity every 6-min in the first 6 h of the forecasts with radar data analysis (enkf\_cn and CN), and
- 2) A netcdf file with the variables in the table with a \* including these variables: Bunkers u and v, echotops, PWAT, downdraftmax, 850 spec hum, 2m qv in addition to the starred variables at this moment

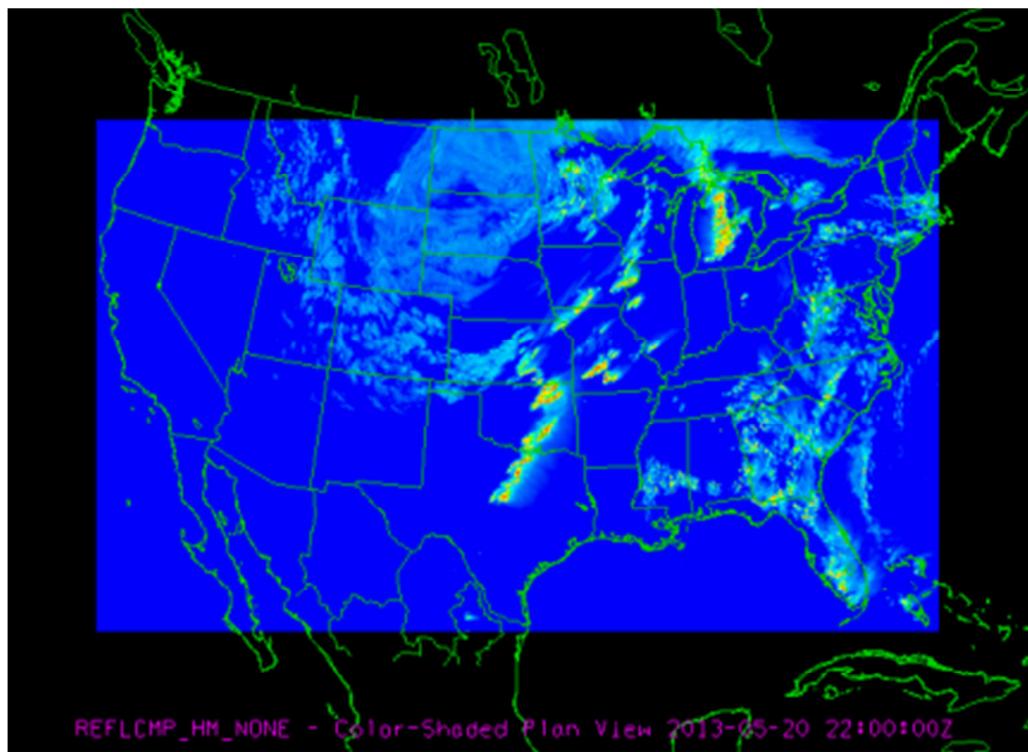


Figure 2. NSSL/SPC sub-domain for the GEMPAK dataset ( $1430 \times 872$ ).

Table 4. 2D fields of each member for NSSL/SPC

Field	GEMPAK name	Unit	Type	Level
Surface pressure	PRES	hPa	Surface/single layer	0
Sea level pressure	PMSL	hPa	Surface/single layer	0
1-h precipitation	P01M	mm	Surface/single layer	0
Temperature at lowest model level	TMPF*	F	Surface/single layer	0
Dew point at lowest model level	DWPF*	F	Surface/single layer	0
10 m U	UREL	m/s	Surface/single layer	0
10 m V	VREL	m/s	Surface/single layer	0
Surface wind speed (10-m)	WMAGSFC*	m/s	Surface/single	0

			layer	
U lowest model level	URELM	m/s	Surface/single layer	0
V lowest model level	VRELM	m/s	Surface/single layer	0
<u>Wind speed max lowest model level</u>	<u>WMAGM*</u>	m/s	Surface/single layer	0
1 km AGL reflectivity	REFL1KM*	dBZ	Surface/single layer	0
<u>1 km AGL reflectivity</u>	<u>REFL1KM_HM</u>	dBZ	Surface/single layer	0
Composite reflectivity	REFLCMP*	dBZ	Surface/single layer	0
<u>Composite reflectivity</u>	<u>REFLCMP_HM</u>	dBZ	Surface/single layer	0
<u>Reflectivity at -10 C</u>	<u>REFLMTR*</u>	dBZ	Surface/single layer	0
Surface-based CAPE	CAPE*	J/kg	Surface/single layer	0
Most unstable CAPE	MUCAPE*	J/kg	Surface/single layer	0
Surface-based CIN	CINS	J/kg	Surface/single layer	0
Most unstable CIN	MUCINS*	J/kg	Surface/single layer	0
Surface-based LCL	HLCL*	m	Surface/single layer	0
0-1 km AGL SRH	SRH01*	$\text{m}^2/\text{s}^2$	Surface/single layer	0
0-3 km AGL SRH	SRH03*	$\text{m}^2/\text{s}^2$	Surface/single layer	0
<u>Updraft helicity</u>	<u>VHEL*</u>	$\text{m}^2/\text{s}^2$	Surface/single layer	0
<u>0-3 km Updraft helicity</u>	<u>VHEL3KM*</u>	$\text{m}^2/\text{s}^2$	Surface/single layer	0
<u>Sfc-400 hPa max W</u>	<u>VVELMAX*</u>	m/s	Surface/single layer	0
0-1 km AGL wind shear	SHR01*	1/s	Surface/single layer	0
0-6 km AGL wind shear	SHR06*	1/s	Surface/single layer	0
<u>Vertical-integrated Qg</u>	<u>COLQG*</u>	kg/ $\text{m}^2$	Surface/single layer	0
Lightning Threat 3	<u>LTG3_MAX</u>	Flashes/k $\text{m}^2/5\text{min}$	Surface/single layer	0

<u>HAIL Size</u>	<u>HAIL*</u>	inches	Surface/single layer	0
<u>HAIL Size GT at k1</u>	<u>HAIL GT*</u>	inches	Surface/single layer	0
Simulated Satellite Ch. 10.67 BT	SIMSAT3	K	Surface/single layer	0
Sim Satellite Ch. 6.48 BT	SIMSAT2*	K	Surface/single layer	0
<u>max Wind speed (1-km)</u>	<u>WMAG1kmMax</u>	m/s	Surface/single layer	0
W wind 1 km	VVEL1km*	m/s	Surface/single layer	0
mixed-layer CAPE	MLCAPE*	J/kg	Surface/single layer	0
mixed-layer CIN	MLCIN*	J/kg	Surface/single layer	0
0 – 3 km AGL lapse rate	LLLR*	K/km	Surface/single layer	0
700 – 500 mb lapse rate	LR75*	K/km	Surface/single layer	0

Note 1: Simulated satellite BTs: GOES-13 (3.9um, 6.48um, 10.7um)

Note 2: The blue highlighted field denotes a new hail field based on mods made by Greg Thompson to explicitly extract max hail size from the microphysics schemes.

## 4.2 Post-processed ensemble products in GEMPAK

A list of post-processed ensemble products are produced for NSSL/SPC for the 2015 HWT Spring Experiment (see Table 5). The 12 ensemble members contribute to the products, they are:

- |                    |                                   |
|--------------------|-----------------------------------|
| arw_cn, arw_m3~m13 | 12-member (3DVAR-based, baseline) |
| enkf_m**           | 12-member (EnKF-based)            |

The underlined variables refer to hourly (or 4-hr) maximum. There are 103 total fields.

*Table 5. Ensemble post-processed products for NSSL/SPC*

Field	GEMPAK name	Unit	Type	Ens type
Sea level pressure	PMSL	hPa	Surface/single layer	Mean
Sea Level pressure Spread	MSLS	hPa	Surface/single layer	STDEV
850 hPa Z	HGHT850	m	Surface/single layer	Mean
500 hPa Z	HGHT500	m	Surface/single layer	Mean
500 hPa Z Spread	H500S	m	Surface/single layer	Mean

250 hPa Z	HGHT250	m	Surface/single layer	Mean
850 hPa u-wind	UREL850	m/s	Surface/single layer	Mean
850 hPa v-wind	VREL850	m/s	Surface/single layer	Mean
250 hPa u-wind	UREL250	m/s	Surface/single layer	Mean
250 hPa v-wind	VREL250	m/s	Surface/single layer	Mean
500 hPa u-wind	UREL500	m/s	Surface/single layer	Mean
500 hPa v-wind	VREL500	m/s	Surface/single layer	Mean
500 hPa absolute vorticity	AVORT500	1/s	Surface/single layer	Mean
1-h precip	P01M_PM	mm	Surface/single layer	PM-mean
1-h precip	P01M_M	mm	Surface/single layer	Mean
1-h precip	P01M_MX	mm	Surface/single layer	Max
1-h precip $\geq 0.25$ in	PR01MTH1_P	%	Surface/single layer	Prob
1-h precip $\geq 0.50$ in	PR01MTH2_P	%	Surface/single layer	Prob
1-h precip $\geq 1.00$ in	PR01MTH3_P	%	Surface/single layer	Prob
6-h precip	P06M_PM	mm	Surface/single layer	PM-mean
6-h precip	P06M_M	mm	Surface/single layer	Mean
6-h precip	P06M_MX	mm	Surface/single layer	Max
6-h precip $\geq 0.5$ -in	PR06MTH2_P	%	Surface/single layer	Prob
6-h precip $\geq 1.0$ -in	PR06MTH3_P	%	Surface/single layer	Prob
6-h precip $\geq 2.0$ -in	PR06MTH4_P	%	Surface/single layer	Prob
Lowest model level temp	TMPF	F	Surface/single layer	Mean
Lowest model level dew point	DWPF	F	Surface/single layer	Mean
precipitable water	PWAT	mm	Surface/single layer	Mean
10 m U	UREL	m/s	Surface/single layer	Mean
10 m V	VREL	m/s	Surface/single layer	Mean
1 km AGL reflectivity	REFL1KM	dBZ	Surface/single layer	PM-mean
1 km refl $\geq 40$ dBZ	REFL1KMTH1_PN	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
4-hr max 1 km refl $\geq 40$ dBZ	REFL1KM_4h_PN	dBZ	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)

Composite reflectivity	REFLCMP	dBZ	Surface/single layer	PM-mean
Comp refl $\geq$ 40 dBZ	REFLCMPTH1_PN	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Surface-based CAPE	CAPE	J/kg	Surface/single layer	Mean
Surface-based CIN	CIN	J/kg	Surface/single layer	Mean
Surface-based LCL	HLCL	m	Surface/single layer	Mean
<u>Max Updraft helicity</u>	VHEL	$m^2/s^2$	Surface/single layer	Max
<u>Updraft helicity <math>\geq 25 m^2/s^2</math></u>	VHEL25	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Updraft helicity <math>\geq 50 m^2/s^2</math></u>	VHEL50	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Updraft helicity <math>\geq 75 m^2/s^2</math></u>	VHEL75	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Updraft helicity <math>\geq 100 m^2/s^2</math></u>	VHEL100	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Max Updraft helicity (4-hr)</u>	VHEL_4h	$m^2/s^2$	Surface/single layer	Max
<u>Updraft helicity (4 hr) <math>\geq 25 m^2/s^2</math></u>	VHEL25_4hr	$m^2/s^2$	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Updraft helicity (4-hr) <math>\geq 50 m^2/s^2</math></u>	VHEL50_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Updraft helicity(4-hr) <math>\geq 100 m^2/s^2</math></u>	VHEL100_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Max sfc-400 hPa W</u>	VVELMAX	m/s	Surface/single layer	Max
<u>Max sfc-400 hPa W <math>\geq 10 m/s</math></u>	VVELMAX10	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Max sfc-400 hPa W <math>\geq 20 m/s</math></u>	VVELMAX20	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Max sfc-400 hPa W (4-hr)</u>	VVELMAX_4h	m/s	Surface/single layer	Max
mlCAPE	MLCAPE	J/kg	Surface/single layer	Mean
mlCIN	MLCIN	J/kg	Surface/single layer	Mean
muCAPE	MUCAPE	J/kg	Surface/single layer	Mean
muCIN	MUCIN	J/kg	Surface/single layer	Mean
0 – 3 km AGL lapse rate	LLLR	K/km	Surface/single layer	Mean

700-500 mb lapse rate	LR75	K/km	Surface/single layer	Mean
<u>Max sfc-400 hPa W (4-hr) ≥ 10 m/s</u>	VVELMAX10_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Max sfc-400 hPa W (4-hr) ≥ 20 m/s</u>	VVELMAX20_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>0-3 km Updraft helicity</u>	VHEL3KM	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	Max
<u>0-3km updraft helicity &gt;= 20</u>	VHEL3km20	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>0-3 km Updraft helicity (4-hr)</u>	VHEL3KM_4h	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	Max
<u>0-3km Updraft helicity (4hr) &gt;= 20 m<sup>2</sup>/s<sup>2</sup></u>	VHEL3P_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
0-1 km AGL wind shear	SHR01	1/s	Surface/single layer	Mean
0-1 km AGL wind shear ≥ 10 m/s	SHR01_10	%	Surface/single layer	Prob
0-1 km AGL wind shear ≥ 15 m/s	SHR01_15	%	Surface/single layer	Prob
0-1 km AGL wind shear ≥ 20 m/s	SHR01_20	%	Surface/single layer	Prob
0-6 km AGL wind shear	SHR06	1/s	Surface/single layer	Mean
0-6 km AGL wind shear ≥ 15 m/s	SHR06_15	%	Surface/single layer	Prob
0-6 km AGL wind shear ≥ 20 m/s	SHR06_20	%	Surface/single layer	Prob
0-6 km AGL wind shear ≥ 25 m/s	SHR06_25	%	Surface/single layer	Prob
<u>Vertical-integrated Qg</u>	COLQG	kg/ m <sup>2</sup>	Surface/single layer	Max
<u>Vertical-integrated Qg ≥ 40</u>	COLQG40	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Vertical-integrated Qg (4-hr)</u>	COLQG_4h	kg/ m <sup>2</sup>	Surface/single layer	Max
<u>Vertical-integrated Qg (4-hr) ≥ 40</u>	COLQG40_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Wind speed lowest model level</u>	WMAGM	m/s	Surface/single layer	Max
<u>Wind speed lowest model level 4-h)</u>	WMAGM_4h	m/s	Surface/single layer	Max
<u>Wind speed lowest model level (4-h) &gt;= 15 m/s</u>	WMAGM15_4hr	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Surface wind speed (10-m)</u>	WMAGSFC	m/s	Surface/single layer	Max
<u>Surface wind speed (10-m) ≥ 15 m/s</u>	WMAGSFC15	%	Surface/single layer	Prob-neighbor (ROI=40,

				sigma=10)
<u>Surface wind speed (10-m) ≥ 25 m/s</u>	WMAGSFC25	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Surface wind speed (10-m) (4-hr)</u>	WMAGSFC_4h	m/s	Surface/single layer	Max
<u>Surface wind speed (10-m) (4-hr) ≥ 15 m/s</u>	WMAGSFC15_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
<u>Surface wind speed (10-m) (4-hr) ≥ 25 m/s</u>	WMAGSFC25_4h	%	Surface/single layer	Prob-neighbor (ROI=40, sigma=10)
Significant Tornado Parameter ≥ 1	SIGTOR1	%	Surface/single layer	Prob
Significant Tornado Parameter ≥ 3	SIGTOR3	%	Surface/single layer	Prob
Significant Tornado Parameter ≥ 5	SIGTOR5	%	Surface/single layer	Prob
Supercell Comp. Parameter ≥ 1	SCP1	%	Surface/single layer	Prob
Supercell Comp. Parameter ≥ 9	SCP9	%	Surface/single layer	Prob
IR Brightness Temp. ≤ -32C	BTN32	%	Surface/single layer	Prob
IR Brightness Temp. ≤ -52C	BTN52	%	Surface/single layer	Prob
Hail size	HAIL	in	Surface/single layer	Max
Hail Size > 0.25"	HAIL0	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size >= 1in"	HAIL1	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size >= 2in"	HAIL2	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size (4 hr)	HAIL_4H	in	Surface/single layer	Max
Hail Size (4 h) >= 1in	HAIL1_4H	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size (4 h) >= 2in	HAIL2_4H	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail size GT	HAIL_GT	in	Surface/single layer	Max
Hail Size > 0.25" GT	HAIL0_GT	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size >= 1in" GT	HAIL1_GT	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size >= 2in"GT	HAIL2_GT	%	Surface/single layer	Prob neighbor

				(ROI=40, sigma=10)
Hail Size (4 hr) GT	HAIL_4H_GT	in	Surface/single layer	Max
Hail Size (4 h) >= 1in GT	HAIL1_4H_GT	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)
Hail Size (4 h) >= 2in GT	HAIL2_4H_GT	%	Surface/single layer	Prob neighbor (ROI=40, sigma=10)

\*The blue highlighted fields are new hail fields based on modifications Greg Thompson is implementing to explicitly extract max hail sizes from the microphysics schemes.

### 4.3 Products that will be extracted and archived as 2D HDF4 files

Table 6 lists the 2D fields that are produced and archived in HDF4 format over the full domain for each ensemble member.

*Table 6. 2D fields archived for CAPS post-analysis*

Field	Variable name	Variable ID	Unit	Type	Level
Surface pressure	PRES	sfpres	hPa	Surface/single layer	0
Sea level pressure	PMSL	mspres	hPa	Surface/single layer	0
1-h precipitation	P01M	aceppt	mm	Surface/single layer	0
Precipitable water	PWAT	pwat_	mm	Surface/single layer	0
2 m temperature	TMPF	temp2m	F	Surface/single layer	0
2 m dew point	DWPF	dewp2m	F	Surface/single layer	0
2 m mixing ratio	MIXR	qv2m_	g/kg	Surface/single layer	0
1st level temperature	TMPF	tempk2	F	Surface/single layer	0
1st level dew point	DWPF	dewpk2	F	Surface/single layer	0
1st level mixing ratio	MIXR	qvk2_	g/kg	Surface/single layer	0
<u>1<sup>st</sup> level wind speed</u>	<u>WMAGM</u>	wsp2mx	m/s	Surface/single layer	0
10 m U	UREL	u10m_	m/s	Surface/single layer	0
10 m V	VREL	v10m_	m/s	Surface/single layer	0
<u>Surface wind speed (10-m)</u>	<u>WMAGSFC</u>	wspmax	m/s	Surface/single layer	0
<u>Wind speed (1-km)</u>	<u>WMAG1KM</u>	wsp1km	m/s	Surface/single layer	0
Surface geo- height	HGHT	hgtsfc	m	Surface/single layer	0

1 km AGL reflectivity	REFL1KM	ref1km	dBZ	Surface/single layer	0
<u>1 km AGL reflectivity</u>	<u>REFL1KM_HM</u>	refmax	dBZ	Surface/single layer	0
4 km AGL reflectivity	REFL4KM	ref4km	dBZ	Surface/single layer	0
Composite reflectivity	REFLCMP	cmpref	dBZ	Surface/single layer	0
<u>Composite reflectivity</u>	<u>REFLCMP_HM</u>	crefmx	dBZ	Surface/single layer	0
<u>Reflectivity at -10C</u>	<u>REFLMTR</u>	r10cmx	dBZ	Surface/single layer	0
Surface-based CAPE	CAPE	sbcape	J/kg	Surface/single layer	0
Moist unstable CAPE	MUCAPE	mucape	J/kg	Surface/single layer	0
Mixed-layer CAPE	MLCAPE	mlcape	J/kg	Surface/single layer	0
Surface-based CIN	CINS	sbcins	J/kg	Surface/single layer	0
Moist unstable CIN	MUCINS	mucins	J/kg	Surface/single layer	0
Mixed-layer CIN	MLCINS	mlcins	J/kg	Surface/single layer	0
Surface-based LCL	HLCL	sblcl_	m	Surface/single layer	0
0-1 km AGL SRH	SRH01	srh01_	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	0
0-3 km AGL SRH	SRH03	srh03_	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	0
<u>Updraft helicity</u>	<u>VHELMAX</u>	uh_max	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	0
<u>Updraft helicity - E</u>	<u>VHELE</u>	uhemax	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	0
<u>Updraft helicity - P</u>	<u>VHELF</u>	uhpmax	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	0
<u>0-3km Updraft helicity</u>	<u>VHEL3KM</u>	uh03mx	m <sup>2</sup> /s <sup>2</sup>	Surface/single layer	0
<u>Sfc-400hPa max W</u>	<u>VVELMAX</u>	wupmax	m/s	Surface/single layer	0
<u>Sfc-400hPa min W</u>	<u>VVELMIN</u>	wdnmax	m/s	Surface/single layer	0
0-1 km AGL wind shear	SHR01	shr01_	1/s	Surface/single layer	0
0-6 km AGL wind shera	SHR06	shr06_	1/s	Surface/single layer	0
1-h accumulated snow	SNOW	snow01	mm	Surface/single layer	0
1-h accumulated graupel	GRAUP	grpl01	mm	Surface/single layer	0
1-h accumulated hail	HAIL	hail01	mm	Surface/single layer	0
Bunkers right-moving U	BKU	bku_	m/s	Surface/single layer	0

Bunkers right-moving V	BKV	bkv____	m/s	Surface/single layer	0
Echo top (>= 18 dBZ)	ECHOTOP	echotp	km	Surface/single layer	0
<u>Vertical-integrated Qs</u>	<u>COLQS</u>	cqsmax	kg/ m2	Surface/single layer	0
<u>Vertical-integrated Qg</u>	<u>COLQG</u>	cqgmax	kg/ m2	Surface/single layer	0
<u>Vertical-integrated Qg (0-5km)</u>	<u>LLOG</u>	llqg05	kg/ m <sup>2</sup>	Surface/single layer	0
<u>0-3km lapse rate</u>	<u>LLLR</u>	lllr____	K/km	Surface/single layer	0
700-500hPa lapse rate	LR75	lr75____	K/km	Surface/single layer	0
100 m U	U100M	u100m____	m/s	Surface/single layer	0
100 m V	V100M	v100m____	m/s	Surface/single layer	0
Sfc downward radiation flux	RADDN	raddn____	W/ m <sup>2</sup>	Surface/single layer	0
Qs above surface	QSSFC	qsk2____	g/kg	Surface/single layer	0
Qg above surface	QGSFC	qgk2____	g/kg	Surface/single layer	0
Qh above surface	QHSFC	qhk2____	g/kg	Surface/single layer	0
Ns above surface	QNSSF	qnsk2____	g/kg	Surface/single layer	0
Ng above surface	QNGSF	qngk2____	g/kg	Surface/single layer	0
Nh above surface	QNHSF	qnhk2____	g/kg	Surface/single layer	0
Qt above surface	QTSFC	qtsfc____	g/kg	Surface/single layer	0
<u>Hail size</u>	<u>HAILSIZE</u>	hailsz	mm	Surface/single layer	0
<u>GT Hail size at k1</u>	<u>HAILSIZE_k1</u>	hailk1	mm	Surface/single layer	0
<u>GT Hail size in column</u>	<u>HAILSIZE_2d</u>	hail2d	mm	Surface/single layer	0
500 hPa absolute vorticity	VORT500	vr500	1/s	Surface/single layer	0
Lightning flash rate	LTG_MAX	Lg_max	Flashes/km <sup>2</sup> /5 min	Surface/single layer	0
LFC height	LFCH	lfch____	m	Surface/single layer	0
PBL height	PBLH	pblh____	m	Surface/single layer	0
W at PBL top	WPBL	wpbl____	m/s	Surface/single layer	0
Simulated satellite BT Ch 3.90 CRTM	SIMSAT1	btch01	K	Surface/single layer	0
Simulated satellite BT Ch 6.48 CRTM	SIMSAT2	btch02	K	Surface/single layer	0

Simulated satellite BT Ch 10.67 CRTM	SIMSAT3	btch03	K	Surface/single layer	0
Geopotential height 850	HGHT	hgt850	m	pressure	850 hPa
Geopotential height 700	HGHT	hgt700	m	pressure	700 hPa
Geopotential height 600	HGHT	hgt600	m	pressure	600 hPa
Geopotential height 500	HGHT	hgt500	m	pressure	500 hPa
Geopotential height 250	HGHT	hgt250	m	pressure	250 hPa
850 hPa U	UREL	u850_	m/s	pressure	850 hPa
700 hPa U	UREL	u700_	m/s	pressure	700 hPa
600 hPa U	UREL	u600_	m/s	pressure	600 hPa
500 hPa U	UREL	u500_	m/s	pressure	500 hPa
250 hPa U	UREL	u250_	m/s	pressure	250 hPa
850 hPa V	VREL	v850_	m/s	pressure	850 hPa
700 hPa V	VREL	v700_	m/s	pressure	700 hPa
600 hPa V	VREL	v600_	m/s	pressure	600 hPa
500 hPa V	VREL	v500_	m/s	pressure	500 hPa
250 hPa V	VREL	v250_	m/s	pressure	250 hPa
850 hPa W	VVEL	w850_	m/s	pressure	850 hPa
700 hPa W	VVEL	w700_	m/s	pressure	700 hPa
600 hPa W	VVEL	w600_	m/s	pressure	600 hPa
500 hPa W	VVEL	w500_	m/s	pressure	500 hPa
250 hPa W	VVEL	w250_	m/s	pressure	250 hPa
850 hPa T	TMPC	tmp850	C	pressure	850 hPa
700 hPa T	TMPC	tmp700	C	pressure	700 hPa
600 hPa T	TMPC	tmp600	C	pressure	600 hPa
500 hPa T	TMPC	tmp500	C	pressure	500 hPa
250 hPa T	TMPC	tmp250	C	pressure	250 hPa
850 hPa mixing ratio	MIXR	sph850	g/kg	pressure	850 hPa
700 hPa mixing ratio	MIXR	sph700	g/kg	pressure	700 hPa
600 hPa mixing ratio	MIXR	sph600	g/kg	pressure	600 hPa

500 hPa mixing ratio	MIXR	sph500	g/kg	pressure	500 hPa
250 hPa mixing ratio	MIXR	sph250	g/kg	pressure	250 hPa

#### 4.4 Name convention

*SPC/NSSL file name*                    *CAPS web name*

ARW members (3DVAR based):

ssef_s3cn_arw_2015032500	SPC3-EF CN WRFARW Fcst
ssef_s3c0_arw_2015032500	SPC3-EF C0 WRFARW Fcst
ssef_s3m3_arw_2015032500	SPC3-EF M3 WRFARW Fcst
ssef_s3m4_arw_2015032500	SPC3-EF M4 WRFARW Fcst
ssef_s3m5_arw_2015032500	SPC3-EF M5 WRFARW Fcst
ssef_s3m6_arw_2015032500	SPC3-EF M6 WRFARW Fcst
ssef_s3m7_arw_2015032500	SPC3-EF M7 WRFARW Fcst
ssef_s3m8_arw_2015032500	SPC3-EF M8 WRFARW Fcst
ssef_s3m9_arw_2015032500	SPC3-EF M9 WRFARW Fcst
ssef_s3m10_arw_2015032500	SPC3-EF M10 WRFARW Fcst
ssef_s3m11_arw_2015032500	SPC3-EF M11 WRFARW Fcst
ssef_s3m12_arw_2015032500	SPC3-EF M12 WRFARW Fcst
ssef_s3m13_arw_2015032500	SPC3-EF M13 WRFARW Fcst
ssef_s3m14_arw_2015032500	SPC3-EF M14 WRFARW Fcst
ssef_s3m15_arw_2015032500	SPC3-EF M15 WRFARW Fcst
ssef_s3m16_arw_2015032500	SPC3-EF M16 WRFARW Fcst
ssef_s3m17_arw_2015032500	SPC3-EF M17 WRFARW Fcst
ssef_s3m18_arw_2015032500	SPC3-EF M18 WRFARW Fcst
ssef_s3m19_arw_2015032500	SPC3-EF M19 WRFARW Fcst

ssef\_s3m20\_arw\_2015032500      SPC3-EF M20 WRFARW Fcst

ARW members (ENKF based):

enkf\_s3cn\_arw\_2015032500      ENKF3 CN WRFARW Fcst

enkf\_s3m2\_arw\_2015032500      ENKF3 M2 WRFARW Fcst

enkf\_s3m3\_arw\_2015032500      ENKF3 M3 WRFARW Fcst

...

Ensemble summary product:

ssef\_s3ens\_2015032500      (12-member)

enkf\_s3ens\_2015032500

## 5. 3D Visualization

3D fields from the 00Z control run covering a 200x200 grid-point area (600 km x 600 km) region will be extracted from the CONUS domain and shipped to the NWC in real-time. The domain will be centered on the SPC-determined daily area of interest as set on the NSSL HWT web site the previous afternoon. Expected arrival of all 3D files will be by 0800 CDT. Workflow for the 3D data processing is shown in Figure 3.

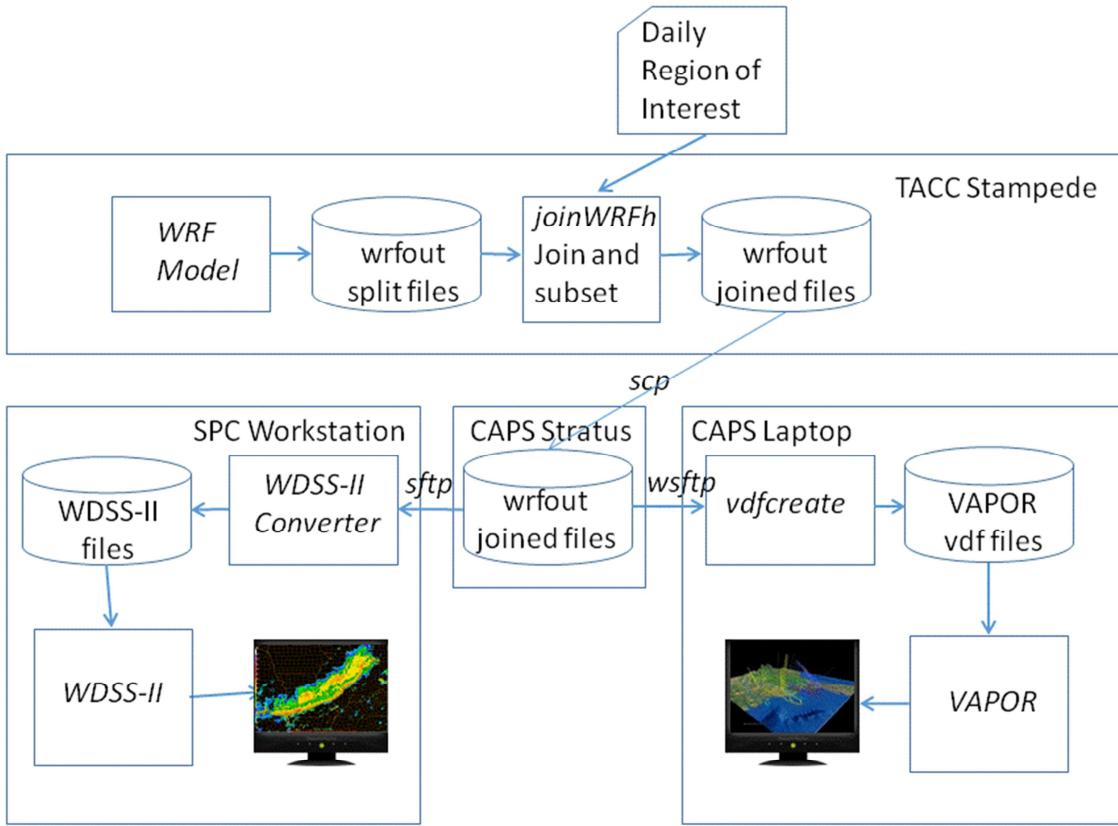


Figure 3. Workflow for 3D data extraction, transmission and 3D visualization processing.

The realtime system will create 10-minute output for 3D visualization from 1800 UTC to 0600 UTC (forecast hours 18-30) on TACC Stampede for the following members: control, m17, m18, m19, m20. The WRF subsetting and join program, joinwrfh, will be queued on Stampede at 0530 CDT each morning to create joined wrfout files of a 600 x 600 km domain centered on the HWT centerpoint of the day. The joinwrf script will include copying of files to Norman where they will be staged on the CAPS cluster (stratus). CAPS personnel, Keith Brewster or Derek Stratman, will copy the wrfout files from there to a laptop to process the 3D fields into vdf files using the VDCWizard tool . Then they will then use the NCAR VAPOR software to display relevant fields of the day for one or more members and present these to the forecast teams and at the HWT briefing at 11am CDT . . A sample static VAPOR field from the 03 June 2014 is shown in Figure 4. Sample WDSS-II fields from a 2014 case are shown in Figure 5, though no use of WDSS-II is planned for HWT 2015 A question about the utility of the 3D visualization and suggestion for additional fields has been added to the HWT forecast questionnaire. The joined wrfout files will be archived on an external harddrive for possible post-realtime analysis.

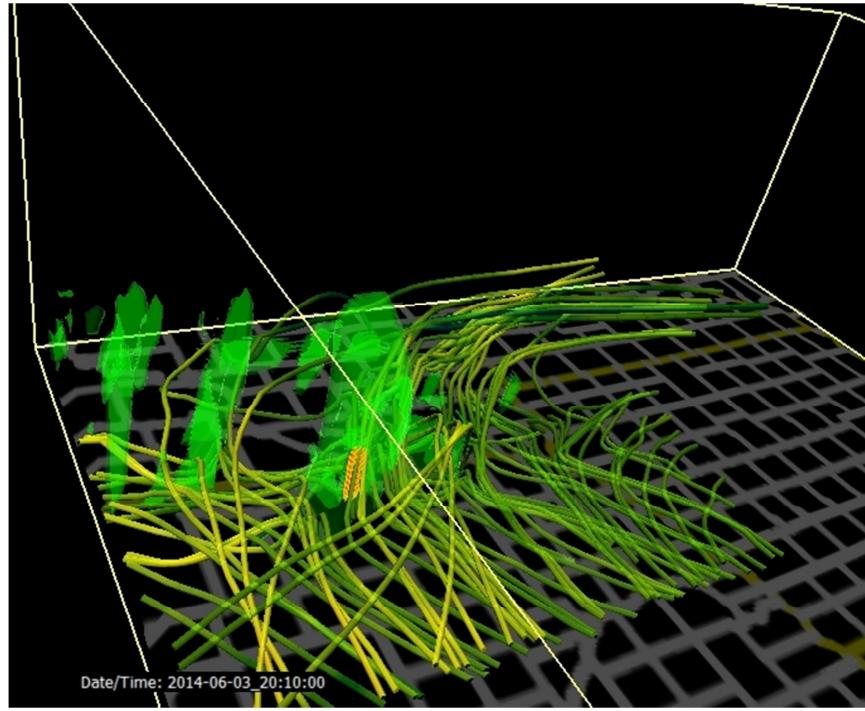


Figure 4. Sample VAPOR visualization from 03 June 2014 showing low-level parcel trajectories, envelope of reflectivity  $> 35 \text{ dBZ}$  and updraft helicity (orange to red shading).

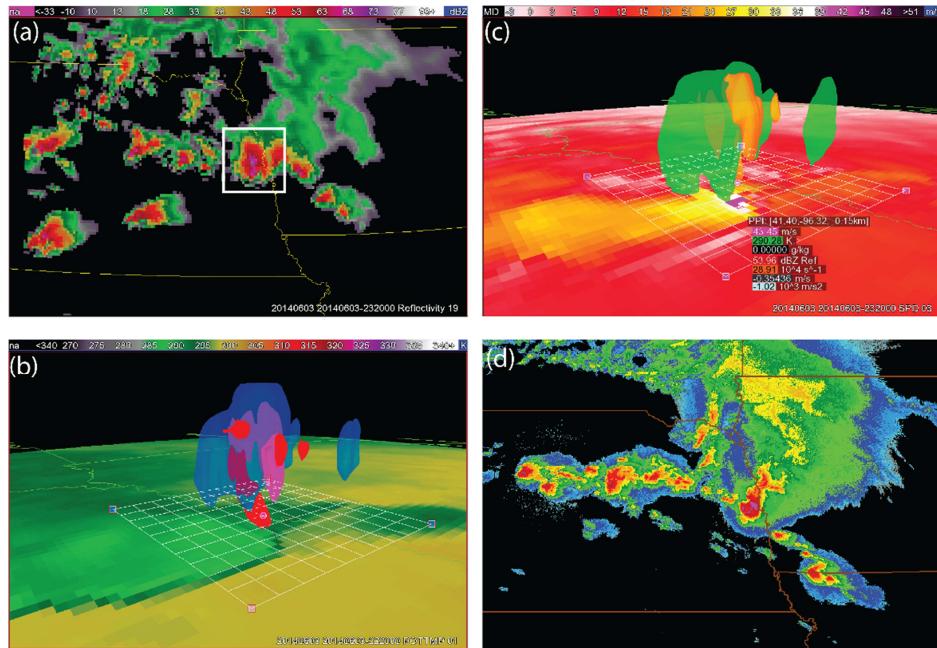


Figure 5. Sample image from WDSS-II model visualization showing reflectivity and other relevant severe weather variables.

## Appendix

### A.1 WRF-ARW timing

### A.2 List of SREF members (Beginning August 2012)

18 perturbed members:

sref\_em\_n1  
sref\_em\_p1  
sref\_em\_n2  
sref\_em\_p2  
sref\_em\_n3  
sref\_em\_p3  
sref\_nmb\_n1  
sref\_nmb\_p1  
sref\_nmb\_n2  
sref\_nmb\_p2  
sref\_nmb\_n3  
sref\_nmb\_p3  
sref\_nmm\_n1  
sref\_nmm\_p1  
sref\_nmm\_n2  
sref\_nmm\_p2  
sref\_nmm\_n3  
sref\_nmm\_p3

3 control members:

sref\_em\_ctl (WRF-ARW)  
sref\_nmm\_ctl (WRF-NMM)  
sref\_nmb\_ctl (NMMB)